APS Low-Energy Undulator Test Line Beam Diagnostics Development

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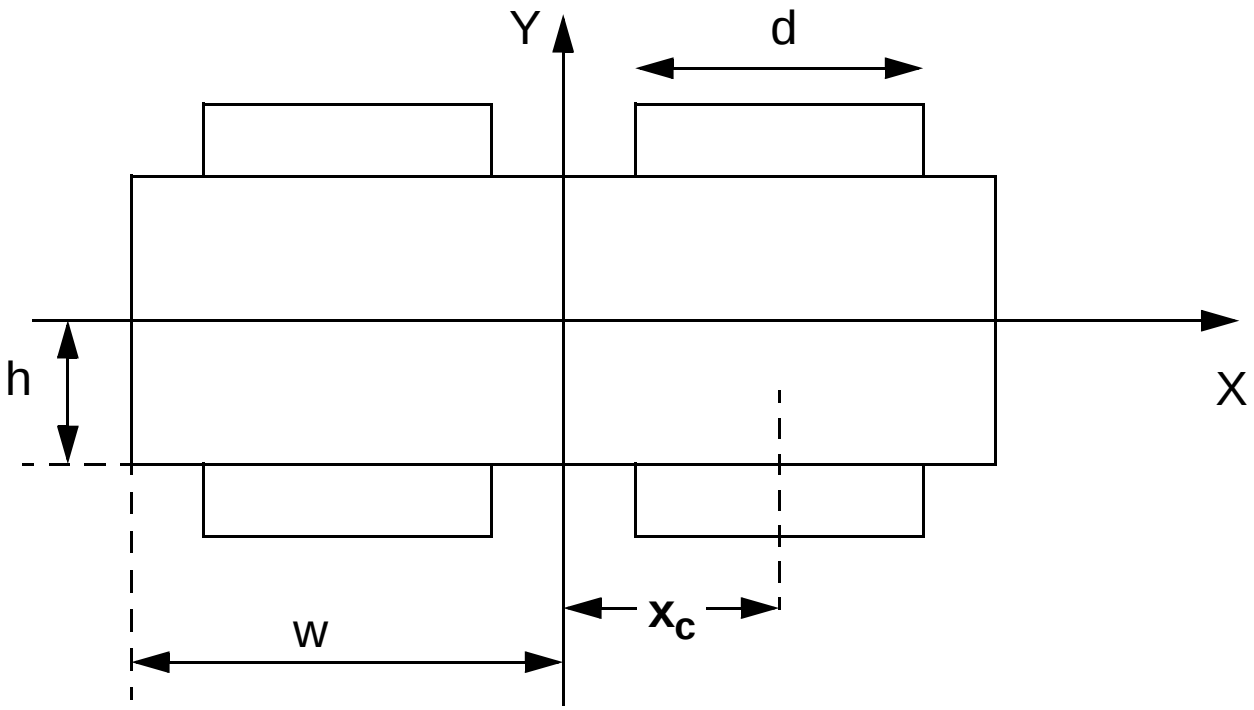
Purpose

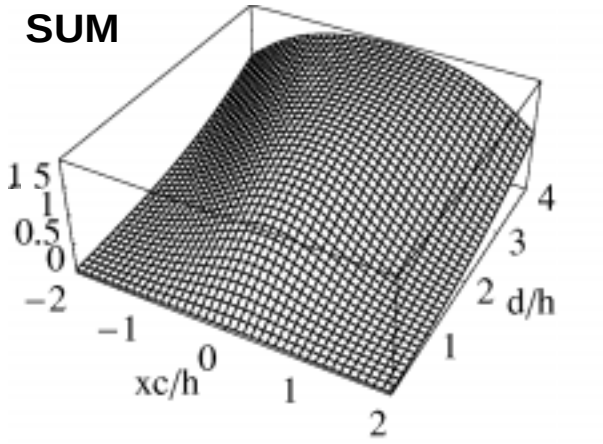
The purpose of this work is to develop particle beam diagnostics for ultra-short, ultra-bright particle beams. Specifically, a high-resolution single-pass beam position monitor (bpm) pickup electrode assembly has been designed, built, and tested, in addition to the development of electro-optic techniques using optical transition radiation. The long-range goal of this work is to support fourth-generation light source development.

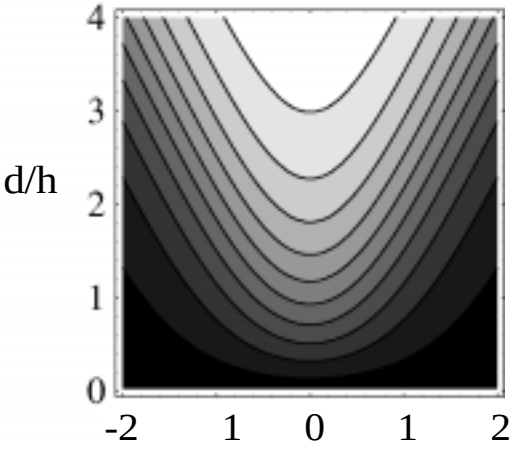
Geometry for BPM button geometry optimization



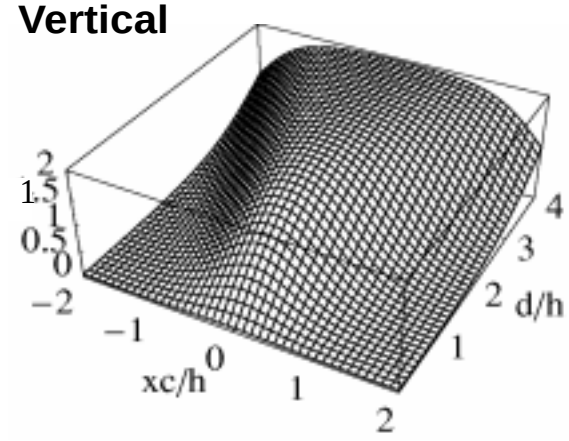
Optimization of BPM Sum, Position Sensitivity with Geometry

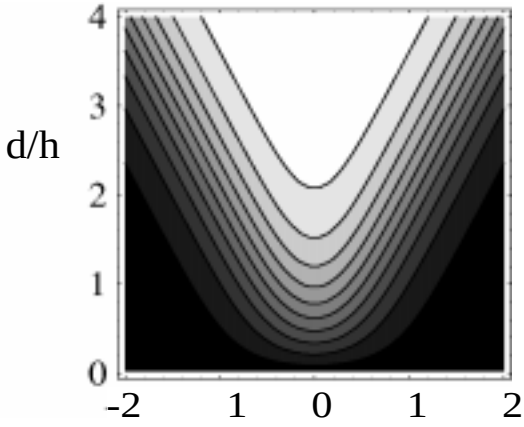
SUM



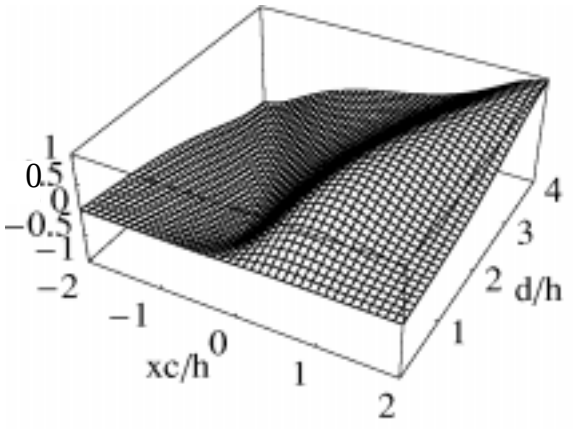


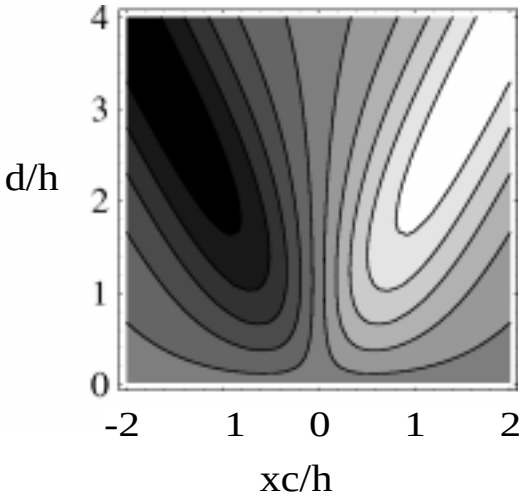
Vertical





Horizontal





Publications

S. Kim, “Optimization of Four-Button Beam Position Monitor Configuration for Small-gap Vacuum Chambers”, Proceedings of the Eighth Beam Instrumentation Workshop, Stanford Linear Accelerator Center, May, 1998 (to be published), also

S.Kim, “Optimization of Four-Button Beam Position Monitor Configuration for Small-gap Vacuum Chambers”, APS Light Source Note LS-266, URL http://www.aps.anl.gov/techpub/lsnotes/ls266/ls266.pdf .

A. Lumpkin, et.al., “Time-Resolved Imaging for the APS Linac Beams”, Proceedings of LINAC’98, 8/23-28/98 (to be published).

A. Lumpkin, et.al., “Optical Techniques for Electron-Beam Characterizations on the APS SASE FEL Project”,Proceedings of FEL’98, 8/16-21/98, (to be published).

A.Lumpkin, et.al., “Linac-Beam Characterizations at 600 MeV Using Optical Transition Radiation (OTR) Diagnostics”, Proceedings of the Eighth Beam Instrumentation Workshop, Stanford Linear Accelerator Center, May, 1998 (to be published).

A. Lumpkin, “Preliminary Tests of the Optical Diagnostics for the APS Low-Energy Undulator Test Line”, Proceedings of FEL’97, (to be published).

A. Lumpkin, et.al. “ Planned Optical Diagnostics for APS Low-Energy Undulator Test Line”, Proceedings of PAC’97. URL http://www.triumf.ca/pac97/papers/index.html

Milestones

I) Verification of performance of small-gap beam position monitor design.

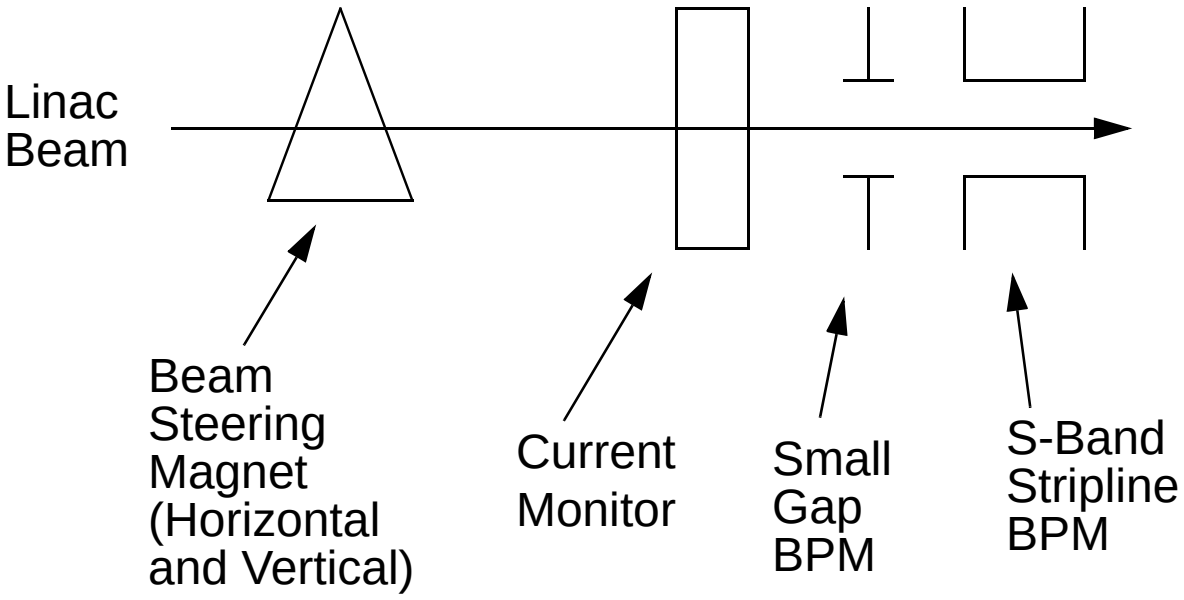
Status: A bpm with 4-mm x 11-mm aperture was fabricated and tested in the LEUTL PAR bypass transport line. A factor of 16 improvement in sensitivity was observed horizontally, and a factor of 19.5 vertically, in comparison with a standard linac stripline pickup electrode design. Signal intensities were observed to be comparable to a nearby stripline pickup. A 2-mm vertical aperture unit is under construction which will provide double the sensitivity of the 4-mm unit, and will be tested in the near future.

II) Refinement of S-band (2.856 GHz) processing electronics.

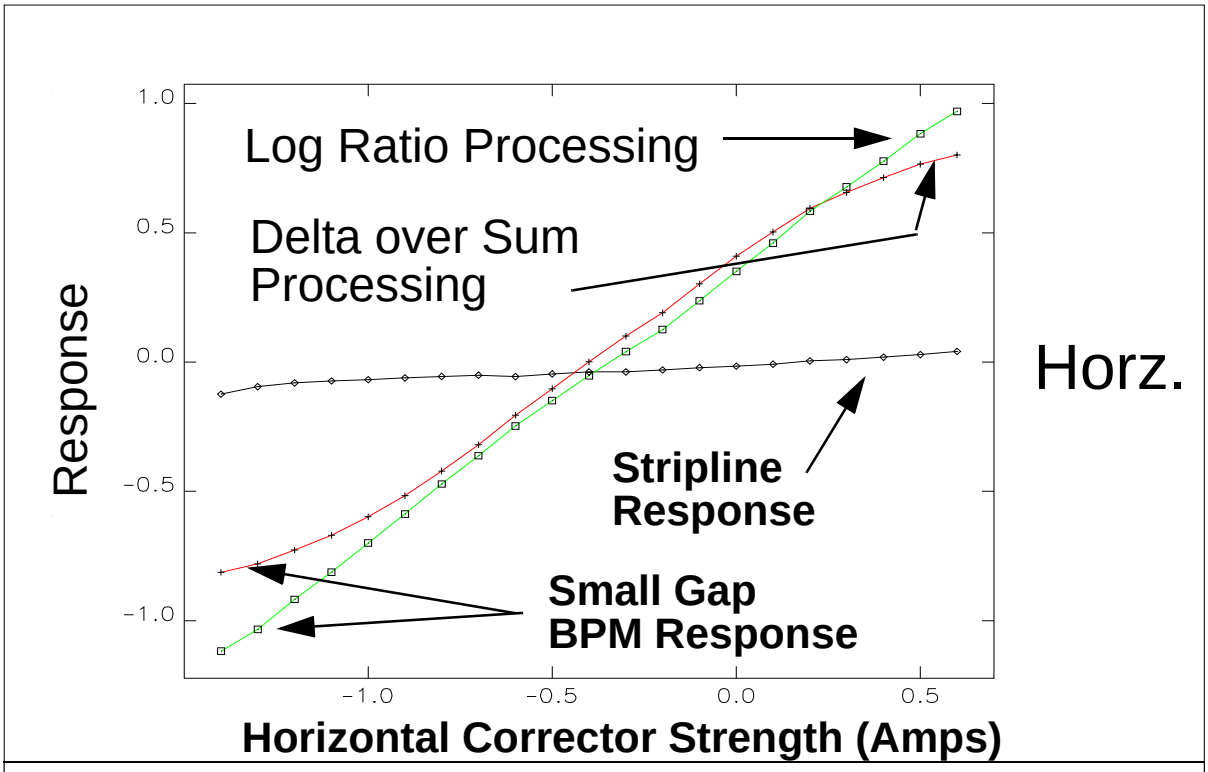
Status: Successfully constructed downconverter chassis for use with new LEUTL beam position monitor striplines and small gap pickups. Further work remaining is to incorporate a newly available, inexpensive logarithmic amplifier which operates up to 500 MHz. (The existing chip has only 100 MHz of bandwidth, while broader bandwidth units have been very costly to date).

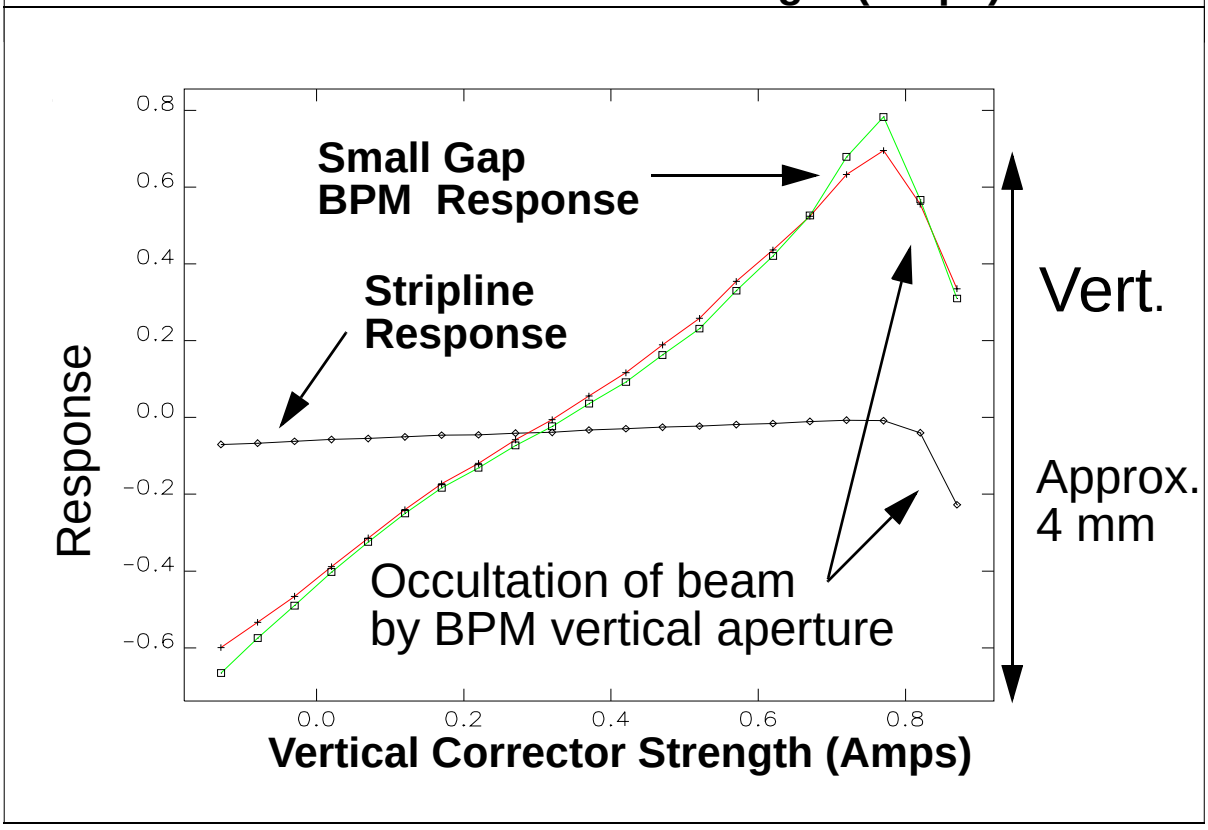
Small Gap Beam Position Monitor Tests

Positron Accumulator Ring Bypass Transport Line



Comparison of Small Gap vs. Standard Stripline BPM





Milestones (cont'd)

III) Tests involving incoherent optical transition radiation (OTR) techniques.

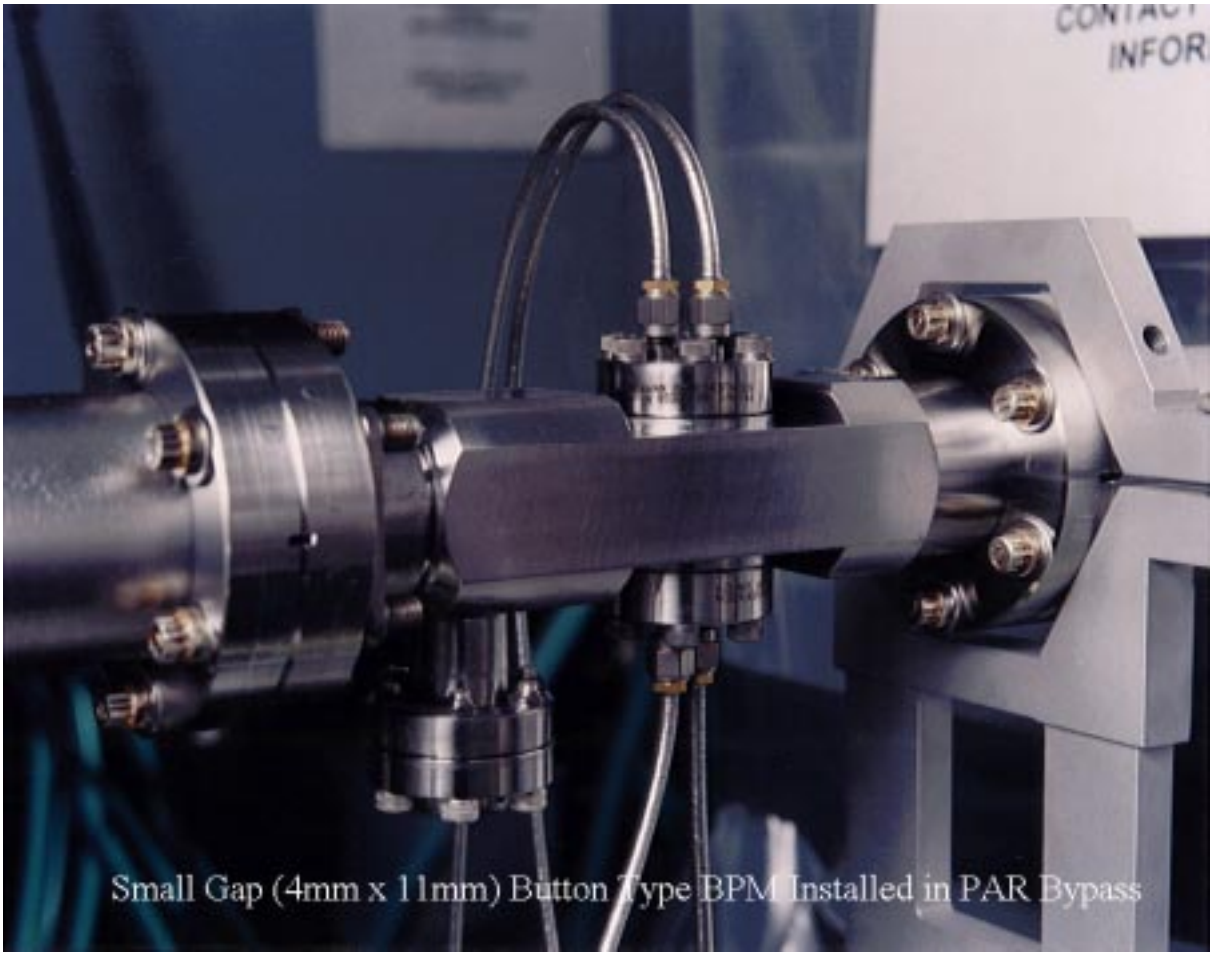
Status: First streak camera measurements of picosecond-scale microbunch dynamics have been performed in the APS Linac. Initial results using the new linac RF gun have been obtained. A comparison study between optical transition radiation and Cerium-doped YAG crystals was conducted, indicating that OTR has superior spatial and time resolution capability albeit with significantly reduced photon flux in comparison to the YAG or standard Chromox beam imaging materials.

IV)Feasibility study for coherent transition radiation and diffraction radiation diagnostics.

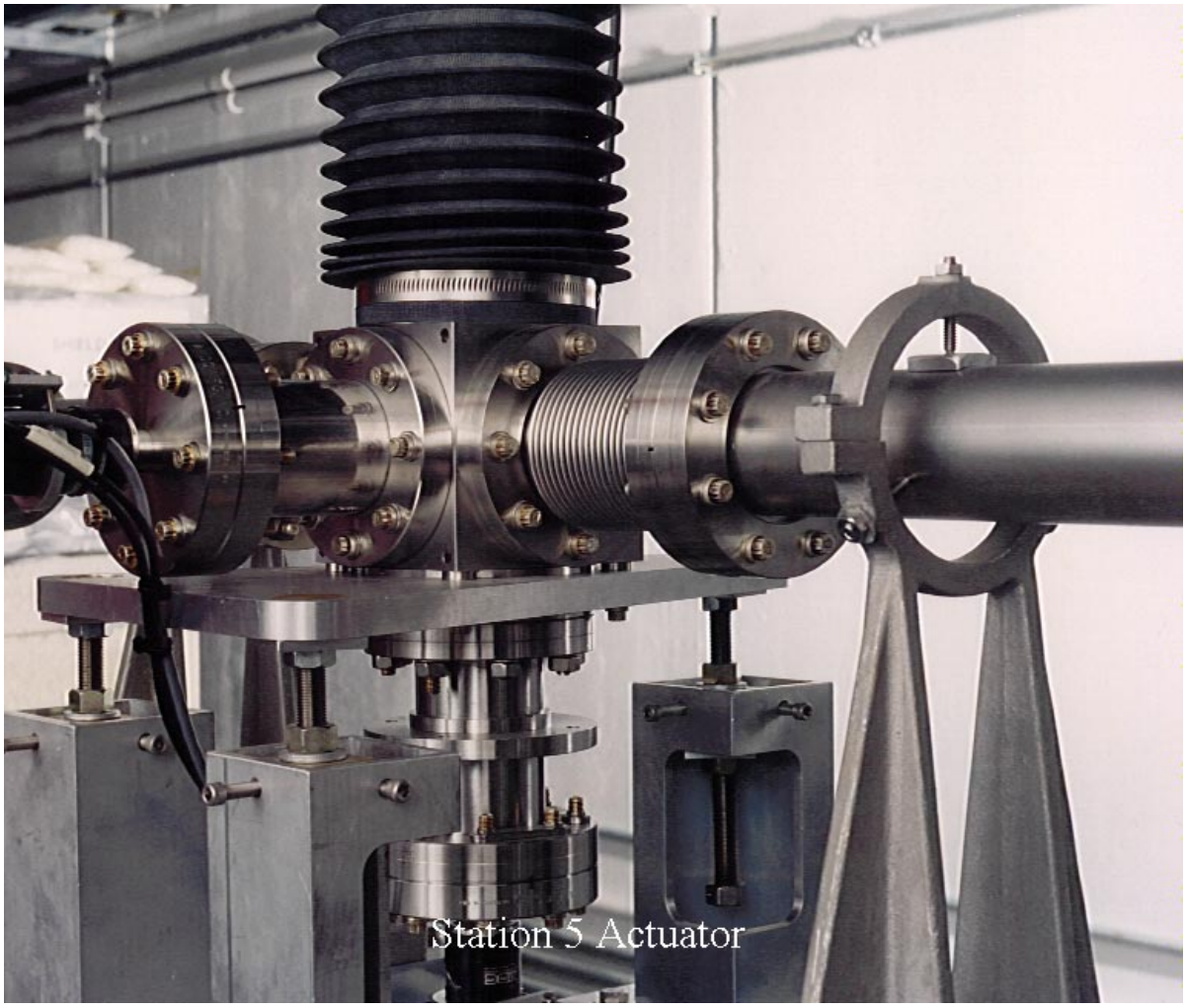
Status: Discussions with other labs, in particular TJNAF (CEBAF) and extensive literature searches have been conducted. This has culminated in a follow-on LDRD proposal.

Table 1: Comparison of the Chromox, YAG and OTR converter Screens for Particle Beam Imaging at 600 MeV at APS

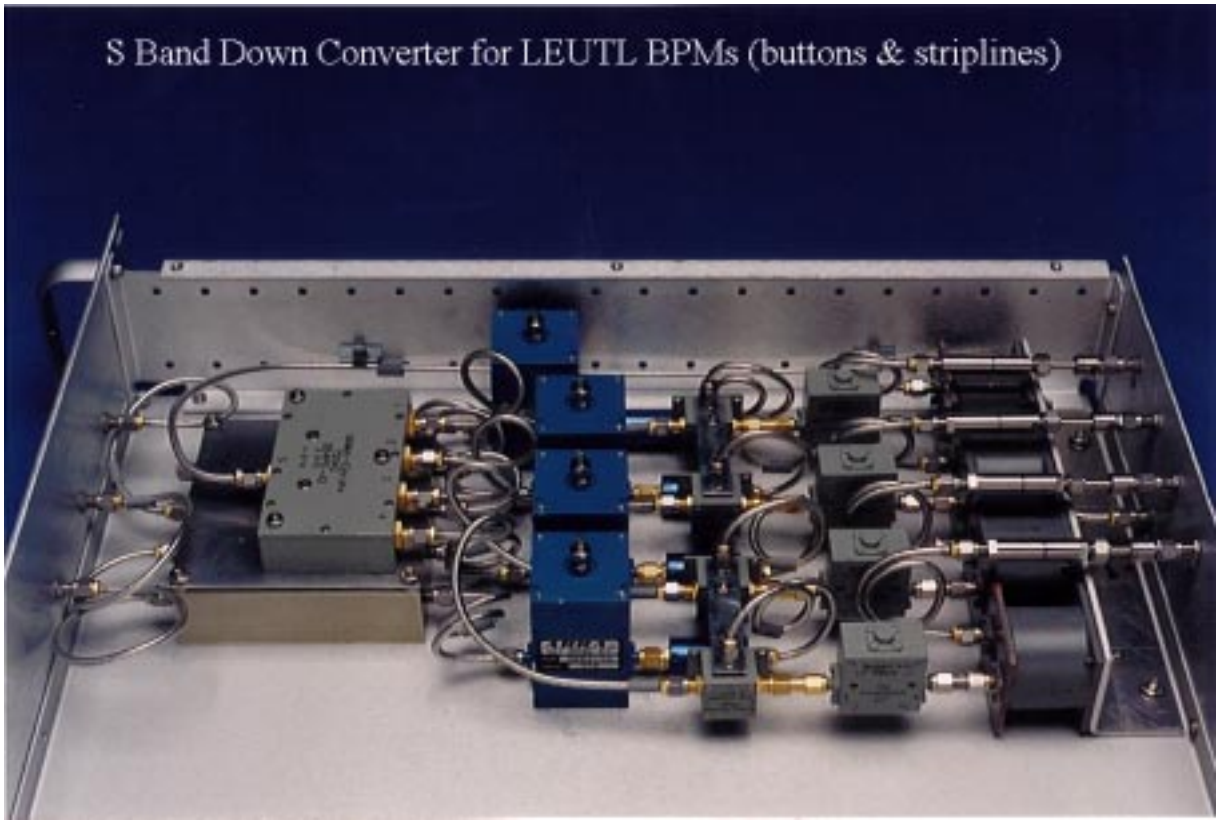
Screen	Spatial Resolution σ (μm)	Temporal Response	Intensity Arb. Units
Chromox (0.25 mm)	200	300 ms	1
YAG (0.5 mm)	<30 @low current <100 @200 mA	80 ns	1
OTR	<10	~ 10 fs	$\sim 2 \times 10^{-3}$

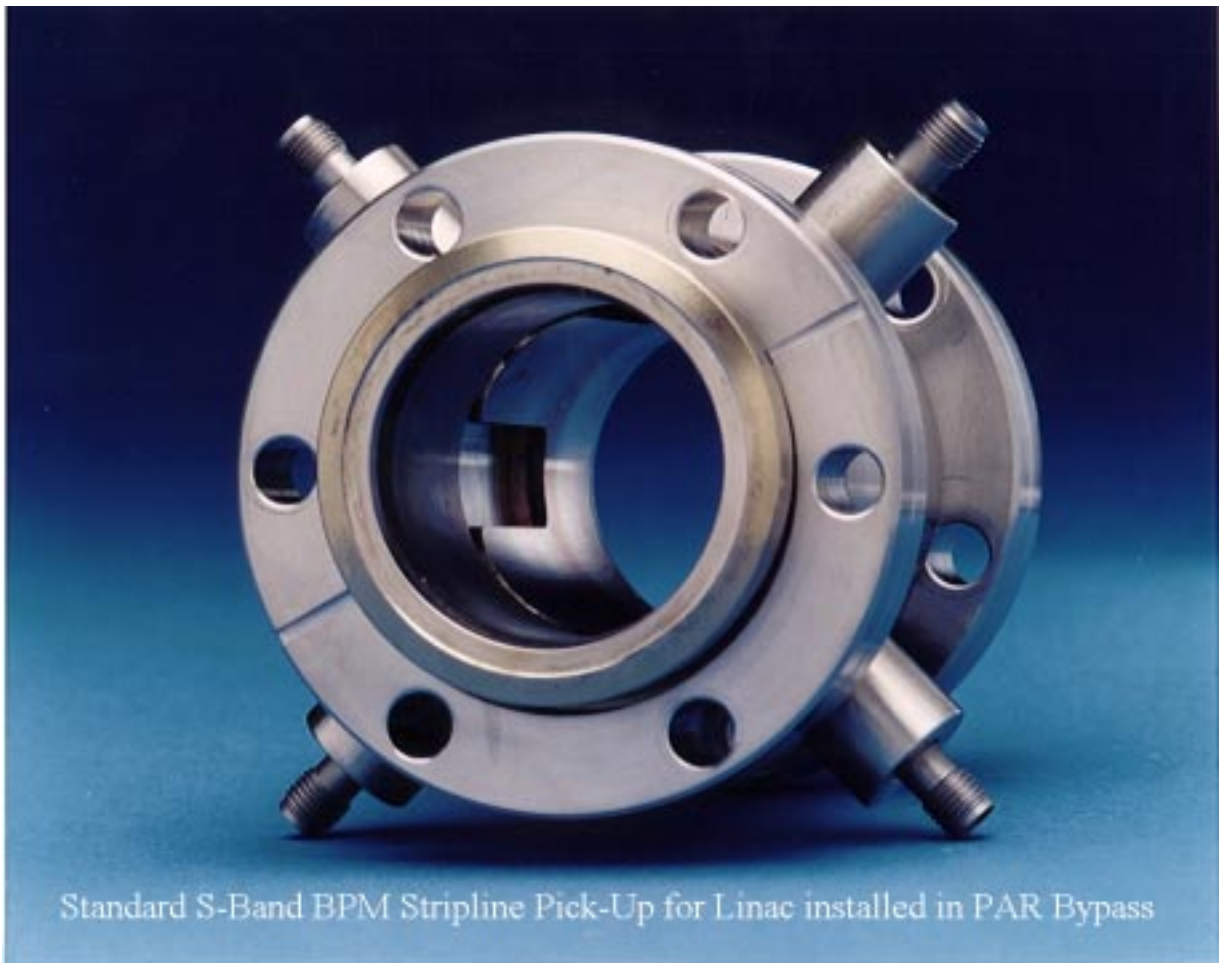


Small Gap (4mm x 11mm) Button Type BPM Installed in PAR Bypass



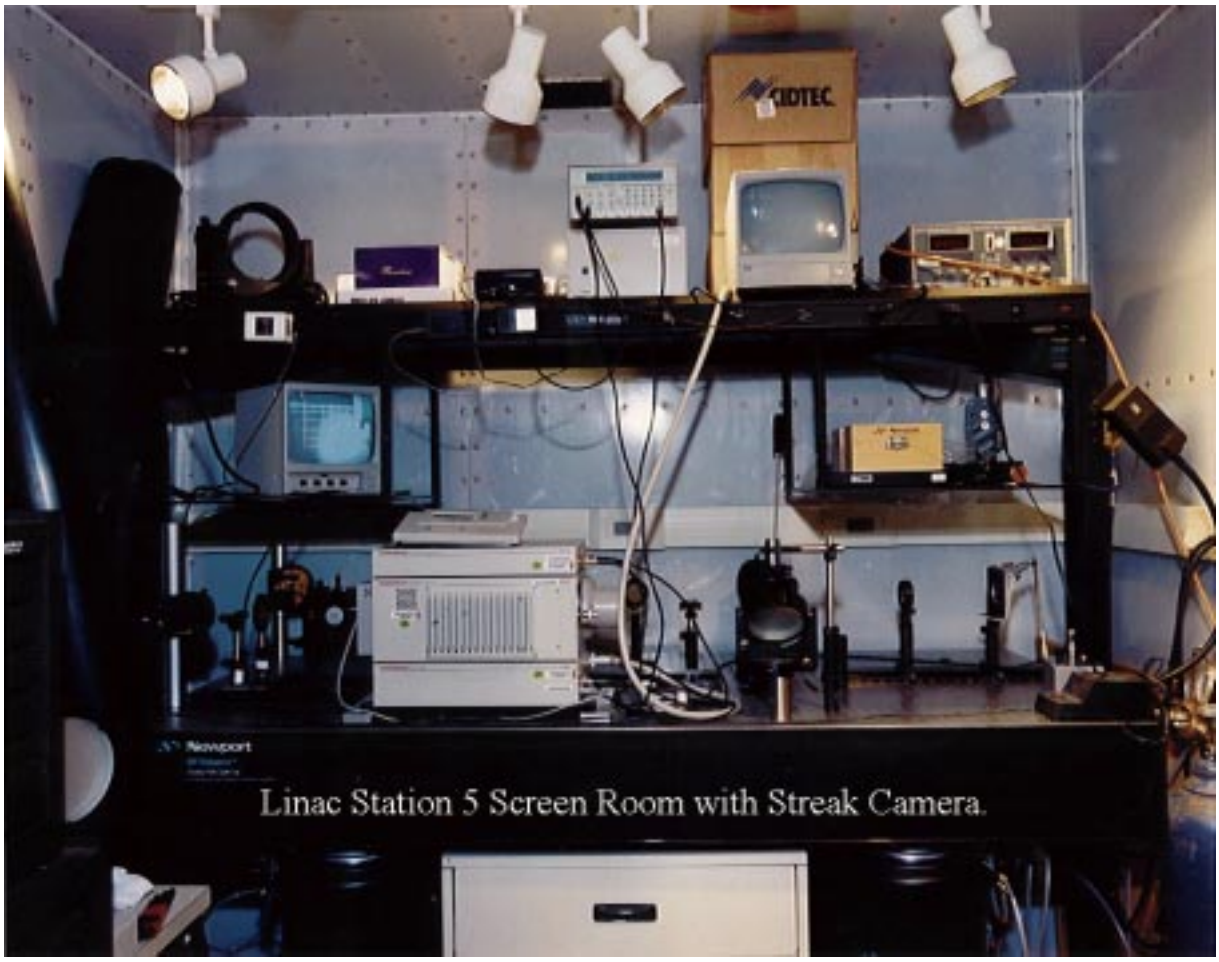
Station 5 Actuator


S Band Down Converter for LEUTL BPMs (buttons & striplines)



Standard S-Band BPM Stripline Pick-Up for Linac installed in PAR Bypass


Small Gap (4mm x 11mm) Button Type BPM



Linac Station 5 Screen Room with Streak Camera.